# Advancing Mechanization in African Agrifood Systems: Unlocking Productivity and Resilience

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# Introduction

This chapter examines the role of mechanization in transforming African agrifood systems within the broader discourse on technological change, structural transformation, and sustainable development. [1] The motivation is to address the persistent challenges of low productivity, rural poverty, labor shortages, and vulnerability to climate change that continue to constrain the agricultural sector across the continent.

Mechanization, broadly defined as the use of tools, implements, and machinery – from basic hand tools to sophisticated motorized equipment – plays a catalytic role in enabling agricultural intensification by reducing drudgery, improving resource efficiency, and enhancing the timeliness and scale of farm operations (FAO 2016; Kirui and von Braun 2018). It is increasingly being recognized not only as a technical input but as a transformative force capable of stimulating growth across the agrifood value chain – from production to processing, marketing, and distribution.

Over the past decade, renewed policy interest in mechanization has emerged, driven by demographic pressures, urbanization, the rise of medium-scale farms, and growing demands for food and labor efficiency (Takeshima, Hatzenbuehler, and Edeh 2020). This has led to regional and continental commitments, such as the African Union's Agenda 2063, the Malabo Declaration, and the Sustainable Agricultural Mechanization in Africa (SAMA) framework, which explicitly call for ending hand-hoe-based agriculture and expanding access to sustainable mechanization technologies.

Despite this momentum, Africa remains the continent with the least mechanization. More than 60 percent of its land is still cultivated manually, with only about 10 percent of agricultural power sourced from tractors or motorized equipment (Kirui 2019; Malabo Montpellier Panel 2018). Smallholder farmers continue to face numerous barriers, including fragmented landholdings, limited access to finance, poor rural infrastructure, weak machinery service markets, and a lack of technical skills. In some countries, policies have also inadvertently distorted machinery markets through unsustainable subsidies or ineffective public-led distribution systems (Diao et al. 2014; Takeshima, Hatzenbuehler, and Edeh 2020).

Yet, there are emerging models that offer hope. These include market-based machinery service provision (e.g., tractor hire schemes), local innovation ecosystems supporting two-wheel tractors and small-scale machinery, and public-private partnerships that tailor solutions to specific agroecological zones. Importantly, mechanization must be inclusive by addressing gender disparities in access to technologies and ensuring that solutions are climate-smart and economically viable.

This chapter investigates how mechanization can contribute to productivity growth, resilience, and inclusive development in African agrifood systems. It draws on empirical literature, regional case studies, and policy frameworks to assess drivers of demand and supply, institutional enablers, and the impact of mechanization across diverse farming systems. The chapter also presents empirical analysis from several countries to shed light on the relationship between mechanization and productivity and resilience. Ultimately, the chapter aims to identify actionable pathways to scale up sustainable mechanization in support of Africa's agricultural transformation agenda.

# Barriers and Enablers of Mechanization

While mechanization is broadly defined as the use of tools, animals, or machines to replace human labor (Kirui and Daum 2021), this chapter focuses on motorized equipment across the agrifood value chain. This includes not only on-farm tools such as tractors but also the technologies used in postharvest handling (e.g., solar driers, threshers, and coolers), processing (e.g., crushers, pressers), and logistics (e.g., motorized transport). These technologies play a crucial role in enhancing productivity, improving efficiency, and reducing postharvest losses (Malabo Montpellier Panel 2018).

At the farm level, mechanization generally leads to productivity gains, labor savings, and production expansion (Daum 2023), especially where it replaces high-drudgery manual tasks. Mechanization can follow six stages. First, draft animals and simple tools assist farmers; second, motorization replaces manual labor in power-intensive operations such as ploughing but not control-intensive operations such as weeding; third, motorized operations begin to takeover control-intensive operations; fourth, farming systems are adapted to

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1  "Agrifood systems comprise the entire range of actors and their interlinked activities that add value in food and non-food agricultural production and related off-farm activities such as food storage, aggregation, postharvest handling, transportation, processing, distribution, marketing, disposal and consumption." (FAO 2023).

mechanization; fifth, specific crops are adapted to meet the needs of mechanized production; sixth, machine intelligence automates mechanized operations (FAO and AUC 2019).[2] While most African countries are in the early stages of this process, the adoption and impact of mechanization are shaped by a combination of demand-side factors (e.g., labor costs, land constraints), supply-side constraints (e.g., cost and availability of machinery), and the broader enabling environment (e.g., infrastructure, policies, service markets).
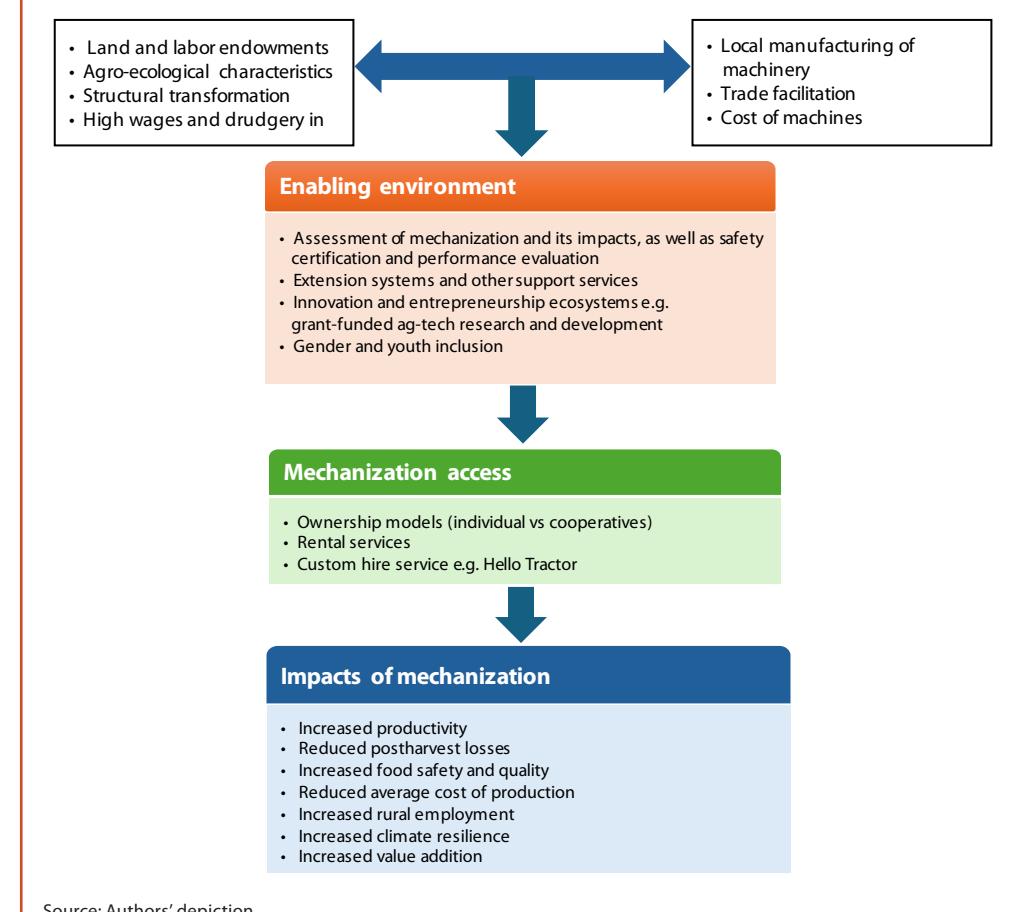
This section draws on the farm system evolution framework, which originated from Boserup (1965) and Ruthenberg (1981) and was adapted to mechanization (Diao, Takeshima, and Zhang 2020; Pingali, Bigot, and Binswanger 1987), to understand how farmers respond to changing factor endowments and policy incentives. As economies structurally transform, drivers of mechanization evolve, and so too do their impacts on labor markets, resilience, and equity. Figure 6.1 presents the conceptual framework summarizing these linkages, which guide the discussion of demand-side and supply-side drivers, enabling conditions, and access models across Africa's five regions.

## Demand-side

In labor-abundant, land-scarce settings – typically characterized by high population densities and smallholder dominance – farming systems are more labor-intensive, and there are more incentives to mechanize tasks that require substantial manual effort (Diao, Takeshima, and Zhang 2020; Pingali, Bigot, and Binswanger 1987). In these systems, mechanization often follows a process of agricultural intensification and tends to emerge first in power-intensive operations, such as land preparation and harvesting – stage two of the mechanization process in FAO and AUC (2019).

Given that most African farmers are smallholders (Lowder, Skoet, and Raney 2016) and that rising populations are leading to further land subdivision, farmers may face stronger incentives to mechanize labor-intensive tasks. Evidence shows large farms tend to mechanize first (Takeshima 2017), as small, fragmented

### FIGURE 6.1—CONCEPTUAL FRAMEWORK



- Land and labor endowments
- Agro-ecological characteristics
- Structural transformation
- High wages and drudgery in

- Local manufacturing of machinery
- Trade facilitation
- Cost of machines

**Enabling environment**
- Assessment of mechanization and its impacts, as well as safety certification and performance evaluation
- Extension systems and other support services
- Innovation and entrepreneurship ecosystems e.g. grant-funded ag-tech research and development
- Gender and youth inclusion

**Mechanization access**
- Ownership models (individual vs cooperatives)
- Rental services
- Custom hire service e.g. Hello Tractor

**Impacts of mechanization**
- Increased productivity
- Reduced postharvest losses
- Increased food safety and quality
- Reduced average cost of production
- Increased rural employment
- Increased climate resilience
- Increased value addition

Source: Authors' depiction.

plots limit the feasibility and profitability of mechanization (Antle and Ray 2020). Across Africa, medium-sized farmers – who are becoming increasingly important in food production (Jayne et al. 2016) – are also paving the way for more mechanized production (Jayne et al. 2019). Meanwhile, small farmers typically cannot afford to buy tractors, and as a result, mechanization services are

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2   The Framework for Sustainable Agricultural Mechanization in Africa (F-SAMA) presented by FAO and AUC (2019) is built on previous FAO work on developing strategies for agricultural mechanization in Africa (FAO 1981).

on the rise (Daum 2023; Diao, Takeshima, and Zhang 2020). Even when offered as a service, the use of mechanization can face challenges due to agroecological conditions and land types. Land areas with uneven terrain, unfavorable soil types, and unpredictable weather conditions can limit machinery performance and adaptability (Daum 2023). For example, evidence shows that mechanization rates are higher in lowlands (Berhane et al. 2020), and Table 6.3 provides further evidence for this trend.

Beyond differences in labor and land endowments and conditions, demand for mechanization tends to increase as countries undergo structural transformation (Daum 2023; Daum and Birner 2020; Diao, Takeshima, and Zhang 2020).

## FIGURE 6.2—DEVELOPMENT INDICATORS BY AFRICAN REGION (1990–2021)
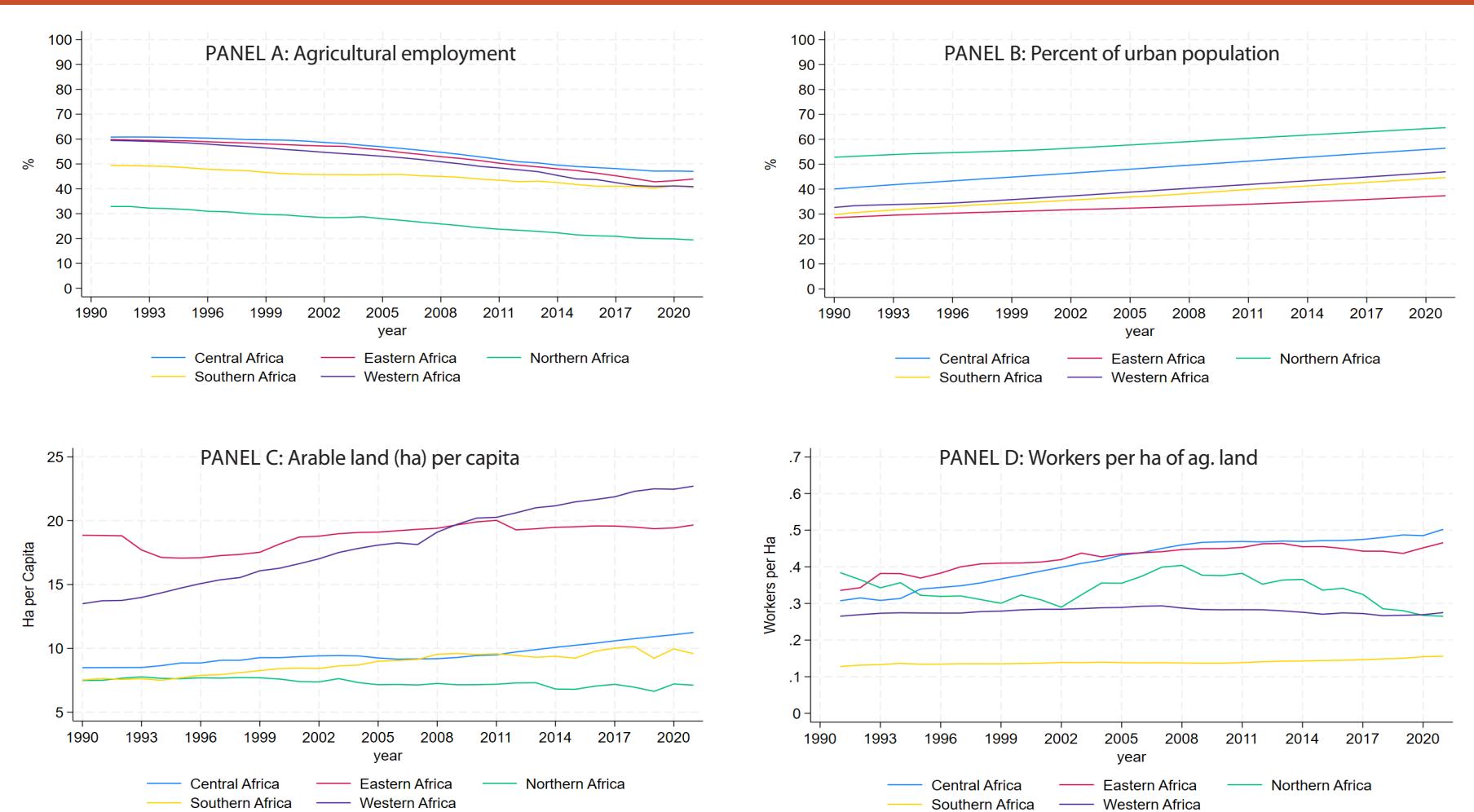


Source: Authors' calculations based on World Bank Development Indicators. Unweighted averages across countries.

When structural transformation occurs, rising rural wages lead to increased opportunity costs for agricultural labor as off-farm jobs become available (Diao et al. 2014). Furthermore, structural transformation is often linked with urbanization and increased demand for agricultural produce – in particular for efficient and easy-to-cook foods – which can increase demand for postharvest processing and mechanization (Diao, Takeshima, and Zhang 2020; Tschirley et al. 2015). Africa is urbanizing (46 percent of people in Africa south of the Sahara lived in urban areas in 2023, and 66 percent in Northern Africa), and urban populations are expected to grow by 950 million by 2050 (OECD 2020), but structural transformation has lagged on the continent (Gollin, Jedwab, and Vollrath 2016). Figure 6.2, Panel A, shows that agricultural employment is decreasing across all regions of Africa, but it still accounts for 40–50 percent of total employment (except in Northern Africa). Combined with barriers to farmers' access to urban markets (De Brauw and Bulte 2021), these dynamics in Africa may temper the demand for mechanization induced by structural transformation.

## Supply-side

Supply-side drivers and barriers correspond to the production, cost, and financing of machinery, as well as the availability of skilled labor to operate machinery. There is limited local manufacturing capacity for agricultural machinery (Daum et al. 2024), largely because the African manufacturing sector has yet to take off. As a result, countries must rely heavily on imports, but imported machines are often poorly adapted to local conditions (Daum 2023; Kaumbutho and Takeshima 2023). Increasing the share of imports from India and China (compared to Western countries) may improve access to lower cost machinery that is also more adaptable to African settings (Singh and Kishida 2018). While many countries have relaxed trade barriers on agricultural machinery, high import duties on

implements and spare parts still exist, which raise the cost of imported machinery. Across the AU regions, ease of trade remains an issue. Central Africa scored the lowest in the World Bank's B-READY (business-ready) trade index (at 34 out of 100) in 2024, and Central Africa also has the lowest levels of machinery stocks and imports out of the five regions. Northern, Southern, and Eastern Africa scored comparatively well in terms of trade scores and also had higher levels of machinery stocks and imports.[3]

Even when tractors are available domestically, their costs remain high, and financing options are limited. Evidence from Asia shows that the high upfront costs of agricultural equipment are a barrier to farmers adopting mechanization (Diao, Takeshima, and Zhang 2020). Tractor prices are on the rise again – since 2020, the cost of tractors in the US (a proxy for global machinery prices) has increased by 32 percent according to Federal Reserve Data. Meanwhile, financing options remain limited for both farmers and mechanization service providers (Daum and Birner 2017). Table 6.1 shows how the B-READY scores for financial services (a proxy for financial access) across the AU regions remain lowest in Central Africa, but do not exceed 70 out of 100 in any country,

### TABLE 6.1—SELECTED INDICATORS BY AU REGION

| | Central Africa | Eastern Africa | Northern Africa | Southern Africa | Western Africa | Total |
|---|---|---|---|---|---|---|
| Logistics performance index: Overall (1–5) | 2.42 | 2.54 | 2.45 | 2.86 | 2.52 | 2.56 |
| % of rural population with access to electricity | 20.14% | 57.40% | 100.00% | 40.80% | 37.81% | 51.23% |
| Financial services: overall score (1–100) | 33.9824 | 58.69 | 62.66 | 61.80 | 47.89 | 53.00 |
| International trade: overall score (1–100) | 34.4359 | 66.59 | 75.26 | 64.63 | 48.76 | 57.94 |
| % of population over 25 having completed secondary education | 12.55% | 36.67% | 42.06% | 61.67% | 30.53% | 36.70% |

Notes: Authors' calculations based on World Bank Development Indicator data. Unweighted averages across countries are reported. Financial services and international trade scores are for 2024 and are derived from the World Bank Business Ready Report (World Bank 2024). Rural electricity coverage is for 2023. Logistics performance index and secondary completion rates are for 2022, with the exception of secondary education competition percentages for Central Africa, which report the latest available figures from 2018.

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3  Imports are based on authors' calculations using COMTRADE data.

indicating that improvements to the financial services sector could enable further mechanization (World Bank 2024).

The availability of skilled labor remains a challenge as well. There is generally a shortage of trained operators, technicians, and dealers for agricultural machinery. Education levels remain low across the continent; Southern Africa is the only region in which more than 50 percent of the population over the age of 25 has completed secondary education (Table 6.1). Increased enrollment and funding for technical and vocational schools could help overcome these challenges.

## Enabling environment

Policy and regulations either constrain or enhance the adoption of mechanization. Many African countries have generally relied on government-led schemes to promote mechanization. However, compared to the Asian experience – where the private sector played a larger role – such schemes are often expensive and unsustainable. Additionally, they often do not address the needs of smallholder farmers (Daum 2023). Private sector provision is growing (e.g., Hello Tractor), but such provision often requires significant financing, and if it is to reach smallholder farmers, policy support is usually needed to lower the customer acquisition costs for private firms.

### *Policy and coordination, regulatory roles*

Unfavorable experiences in government-led mechanization schemes, and other government-led market interventions more broadly, can arise due to government failures, including poor implementation (Akinola 1987; Takeshima et al. 2015), lower efficiency due to the lack of accountability, elite capture and corruption, and limited alignment with farmers' needs (Diao, Silver, and Takeshim 2017; Daum and Birner 2017). Furthermore, coordination failures among public-sector agents, including national and local governments, can further inhibit an enabling environment for the growth of private sector led mechanization (Diao et al. 2014). Similarly, while there is scope for the government's regulatory roles in improving mechanization-related market function, their benefits should be carefully balanced with the potential risks of inadvertent outcomes due to government failures. For example, effective regulation of machine quality and registration systems can improve functionality by reducing breakdowns and improving accountability, if regulatory capacity is sufficient (McFadden 2022).

However, overregulation can disrupt market function when regulatory capacity is limited, as is the case for many countries in Africa south of the Sahara (Diao, Takeshima, and Zhang 2020).

### *Investments in infrastructure, public goods*

Investments in infrastructure can also enable mechanization providers to reach more farmers and be more profitable. Poor rural road networks hinder machinery access, mobility, and repair logistics, as well as increasing the cost of reaching farmers. There is considerable variation across Africa in World Bank-reported logistics performance, with Southern Africa having the highest score and Central Africa the lowest. Similarly, stable electricity access can enable postharvest mechanization (such as threshing, cleaning, sorting, and cooling). However, most rural populations across Africa do not have access to electricity from the grid, which hinders the ability of rural firms to mechanize (Table 6.1).

Relaxing regulation for small-scale generation and local distribution of community-based electricity micro-grids can potentially encourage private investments (e.g., in Kenya (Kirubi et al. 2009)). Encouraging multinational enterprise, alongside foreign direct investment, is also often effective in improving electricity infrastructure and access in Africa south of the Sahara (D'Amelio, Garrone, and Piscitello 2016). Similarly, promoting public-private partnerships (PPPs) – combined with strengthening the public sector's institutional capacity to manage PPPs – is a potentially effective way to develop infrastructure, such as roads, in developing countries (Ncube 2010; Trebilcock and Rosenstock 2015). Particularly in Africa south of the Sahara, reducing sources of inefficiency such as regional favoritism – which often persists from the colonial period – through the reorganization of national road systems, can enhance the efficiency of road construction (Graff 2024). The development of digital infrastructure, while more relevant to the broader economy, is also becoming increasingly important for mobilizing digital technologies for mechanization. For example, financial initiatives such as Universal Access/Universal Service Funds are potential instruments that should be explored (Daum et al. 2022).

Other aspects of the enabling environment are also too often overlooked by many governments in Africa south of the Sahara. Outside of the region, the private sector has historically led adaptive R&D in machinery design and parts modification through reverse engineering and fabrication, while the public sector has played complementary roles in more basic research on engineering

(Diao, Takeshima, and Zhang 2020). The private sector's R&D efforts have often been stimulated by sequential industrialization policies, starting from increased exposure to imported machines (and parts) resulting from trade policies that prioritize market competition and less regulation or barriers, and gradual growth of domestic manufacturing starting from simpler parts and later moving on to more sophisticated implements or machines (Takeshima 2025). In contrast, when governments try to leapfrog that sequence and cause significant policy uncertainty, they often end up adversely affecting private sector innovation in mechanization.

Relevant information and data, another key element of the enabling environment, is also undersupplied by the public sector in Africa south of the Sahara. For example, tractor censuses to assess the local availability of functional tractors – particularly in the informal sector (Diao, Takeshima, and Zhang 2020) – and/or surveys of typical budget structures among private sector actors such as hiring service providers, machines/spare parts retailers, and repair services, can potentially reduce information gaps and lower barriers to entry for local entrepreneurs in mechanization-related businesses (Takeshima 2025).

## Gender and youth inclusion considerations

Agricultural mechanization has the potential to catalyze inclusive rural transformation, but it also risks exacerbating existing structural inequities if not implemented with a gender- and youth-sensitive lens. Women constitute around 50 percent of the agricultural labor force in Africa south of the Sahara and play a pivotal role in on-farm production, postharvest processing, and informal food markets (Palacios-Lopez, Christiaensen, and Kilic 2018). Yet, they remain disproportionately excluded from the benefits of mechanization. This exclusion stems from intersecting barriers, including limited access to land and credit, weaker legal rights, lower literacy rates, gender-blind extension services, limited exposure to mechanization tools, including those for animal traction, and the dominance of male-centered machinery design and dissemination strategies (Gass and Biggs 1993; Murray et al. 2016). For example, lower technical skills among women have been found to prevent the use of machinery in Tanzania (Fischer et al. 2018). In Malawi, patriarchal norms mean women smallholders across all age groups and household sizes have limited access to motorized rural transportation, including public transportation and motorcycles (Murray et al. 2016). In Ethiopia, cultural norms have sometimes considered plowing by

women taboo (Pender, Place, and Ehui 2006), and historically, women have been more engaged in weeding, a task that tends to be mechanized much later than tilling or harvesting (Berhane et al. 2020).

Mechanization often reinforces a gendered division of labor, with men more likely to control capital-intensive tasks such as land preparation and harvesting, while women remain concentrated in manual, labor-intensive postharvest roles. Addressing this imbalance requires purposeful efforts to design and deliver gender-inclusive mechanization pathways. These may include establishing women-led or women-preferred mechanization service hubs, ensuring subsidized access to equipment, and promoting ownership models tailored to women's landholding and financial capacity. For example, in Benin, supporting mechanization services through existing cooperatives that facilitate the sharing of machinery and equipment has successfully improved access to mechanization for vulnerable groups, including women (Houmy, Rojas, and Side 2021). Similarly, the promotion of smaller machines (such as two-wheel tractors) – where they work reasonably well – has generally improved women's access to mechanization technologies, as experienced in Tanzania (Mrema, Kahan, and Agyei-Holmes 2020).

Moreover, targeted skills development and vocational training tailored to women's needs can unlock their participation not only as machinery users but also as operators, service providers, and entrepreneurs in the mechanization ecosystem. For instance, initiatives offering mobile training, flexible schedules, and childcare support have been shown to increase women's uptake of technical education in Morocco and Ethiopia.

It's equally important to harness Africa's youth bulge. With nearly 60 percent of the population being under the age of 25, the continent faces immense pressure to integrate youth into productive agricultural systems, but this is also an opportunity. Mechanization offers an appealing pathway for rural youth who increasingly view traditional farming as unattractive due to its physical demands and low returns (Daum et al. 2022). However, barriers remain, including weak technical training, limited access to start-up capital, and poor rural infrastructure.

To bridge this gap, governments and development partners are investing in vocational schools and agribusiness incubation centers focused on mechanization. Programs such as Morocco's Plan Maroc Vert (PMV) and Ethiopia's Agricultural Mechanization Service Centers (AMSC) provide young people with

training in equipment maintenance, postharvest technology, and precision agriculture tools. These interventions not only improve youth employability but also promote rural industrialization and service economies. In addition, involving youth in policy formulation processes, including those related to mechanization, has been found to be critical for enhancing youth inclusivity in Malawi (Kadzamira and Kazembe 2015).

It is notable that national initiatives such as Morocco's PMV provide valuable lessons on policy-driven mechanization. Launched in 2008, PMV mobilized significant investment in irrigation, machinery, and value chain upgrading, contributing to yield growth and modernization (Malabo Montpellier Panel 2018). Yet evidence also shows that benefits were uneven: large-scale commercial farmers captured most of the subsidies, while smallholders (particularly women and youth) struggled to access finance, land, and services (Daum and Birner 2017). Questions of fiscal sustainability also arose, as the program relied heavily on subsidies that may not be replicable in other contexts.

Comparisons with other African cases highlight similar challenges. Ghana's AMSEC program demonstrated how subsidized service providers can expand tractor access, but persistent issues with maintenance, elite capture, and uneven coverage limited impact (Takeshima et al. 2015; Takeshima, Hatzenbuehler, and Edeh 2020). Ethiopia's partnerships for machinery leasing and local assembly offered tailored solutions for smallholders, but financing and coordination bottlenecks constrained scalability. Together, these experiences show that while national (public) programs can accelerate mechanization, their effectiveness and scalability depend on inclusivity, governance capacity, and long-term market-driven solutions.

In sum, gender and youth inclusion in mechanization is not merely a question of fairness – it is essential to unlocking the full transformative potential of agrifood systems. Policies and programs must be intentional about inclusion, investing in localized, affordable, and accessible technologies, supported by enabling institutions, to ensure that mechanization contributes to equitable, resilient, and prosperous rural livelihoods across the continent.

## Sustainability and resilience

Irregular rainfall patterns, rising temperatures, and an increase in climatic shocks are driving the need for mechanization to be more sustainable and increase the resilience of farmers. Mechanized practices, such as tilling, are often seen to worsen soil health, increasing farmers' vulnerability to climate shocks and reducing their production potential. However, minimum-tillage technologies (e.g., through specific implements such as the chisel ripper) can help make mechanization more sustainable. Mechanization can also improve efficiency and reduce input waste, such as through smart irrigation technologies, seed drills, and efficient sprayers. In terms of emissions, farmers often rely on diesel-powered machines, and switching to electric machinery can be costly. However, some mechanization can also decrease emissions and energy usage. Crop residue management machinery, for example, can replace the practice of burning crop residue, instead converting the residues into usable by-products, such as fertilizer or fodder (UN ESCAP 2022).

Mechanization can have both positive and negative implications for farmers' resilience (Malabo Montpellier Panel 2018). Mechanized processes such as irrigation can increase resilience to droughts, while postharvest interventions along the value chain can increase shelf life and smooth consumption patterns. Mechanization also allows farmers to respond to shocks more quickly due to the reduced labor requirements. On the other hand, reliance on mechanization introduces risks. For example, machines can break down, and in many rural areas across Africa, finding skilled mechanics and the right parts for repairs is a challenge (Kaumbutho and Takeshima 2023). Global fuel prices also fluctuate. In recent years, supply chain disruptions and the Russia-Ukraine conflict have driven up fuel prices and thus the cost of mechanization for smallholder farmers (Glauber and Laborde 2023). Off the farm, disruptions in electricity supply can increase the vulnerability of firms using machines such as coolers. More testing of promising alternatives through pilot programs is needed in such settings. For example, while there is growing evidence on the viability of solar-powered cooling technologies in Africa (Takeshima et al. 2023), more evidence on their scalability is needed.

# Trends in Mechanization Across Africa

This section will explore current patterns of mechanization adoption at regional as well as subnational levels.

## Regional patterns

Agricultural mechanization in Africa, particularly south of the Sahara, has been stagnating for the last three decades. While consistent data on the level of mechanization is hard to obtain, data on the stock of major agricultural machinery offer useful insights. As shown in Figure 6.3, while the level of agricultural machinery

stock per cropland (horsepower per cropland) has increased from about 1,700 hp/1,000 ha in 1990 to 2,800 hp/1,000 ha in 2019 in the Northern Africa region, the figures in the rest of Africa have remained at well below 1,000 hp/1,000 ha throughout this period. While Southern Africa and Eastern Africa have seen slight increases since the late 2000s, the pace has been generally modest.

Importation of agricultural machines has also remained modest over the past few decades, although some regions exhibit relatively higher levels of diversity in the types of machines imported (Table 6.2). Based on COMTRADE data from 2010 to 2023, across the regions, tractors have accounted for significant shares (roughly 40–60 percent) of the overall sets of agricultural machinery imported by each region. Given the generally low level of tractor stocks in Africa, as shown in Figure 6.3, the fact that they still account for the bulk of overall agricultural machinery importation suggests that the importation of other types of machines may also be limited. Nonetheless, some variations exist across regions. For example, imported machinery in Central and Western Africa is more likely to consist of cleaning and sorting machines; in Northern and Western Africa, horticultural and poultry equipment; and in Southern Africa, harvesting and threshing machines – indicating regional diversity in mechanization patterns.

Governments in Africa south of the Sahara have allocated a certain share of their public expenditure to direct support for agricultural mechanization. While the literature provides very limited information on exact figures, some indicative information is provided in studies from Nigeria. One area of public expenditure may involve government-owned fleets of machinery – such as tractors, harvesters, and

## FIGURE 6.3—TRENDS IN MECHANIZATION STOCKS BY REGION (1990–2019)
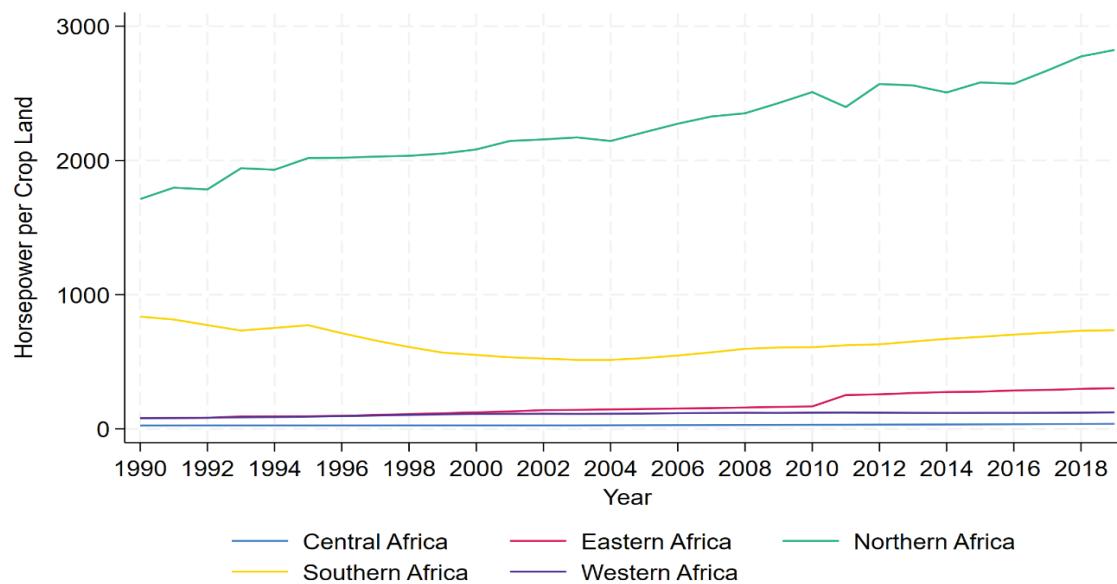


Source: Authors' calculations based on USDA (United States Department of Agriculture) Economic Research Service, International Agricultural Productivity Project. (https://www.ers.usda.gov/data-products/international-agricultural-productivity.)

## TABLE 6.2—IMPORTS BY TYPE AND REGION (2010–2023)

| | Central Africa | Eastern Africa | Northern Africa | Southern Africa | Western Africa | Total |
|---|---|---|---|---|---|---|
| Tractors | 54.29% | 51.04% | 59.47% | 45.44% | 40.03% | 50.00% |
| Land preparation machines | 4.46% | 4.75% | 2.59% | 8.09% | 6.95% | 5.38% |
| Harvesting and threshing machines | 3.11% | 6.00% | 6.65% | 14.63% | 3.78% | 6.88% |
| Cleaning and sorting machines | 13.75% | 8.53% | 5.09% | 6.22% | 16.51% | 9.97% |
| Presses and crushers | 1.91% | 0.64% | 0.38% | 0.65% | 0.89% | 0.88% |
| Milking and dairy machines | 1.03% | 1.54% | 1.75% | 1.67% | 1.01% | 1.41% |
| Agricultural, horticultural, poultry, and apicultural machinery | 3.87% | 4.33% | 7.63% | 5.86% | 7.18% | 5.80% |
| Other machinery | 17.58% | 23.17% | 16.45% | 17.42% | 23.66% | 19.68% |

Source: Authors' calculations based on COMTRADE data.

other implements – used for public hiring services, including their procurement, refurbishment, and maintenance. For example, though somewhat outdated, a detailed public expenditure study for the Bauchi state government in Nigeria, showed that 8 percent of state agricultural spending went to agricultural machinery services in the early 2000s (Mogues et al. 2008, p.40). In later years, some states in Nigeria allocated more of their public expenditure to subsidies for tractors procured by private sector tractor owners. For example, in Kaduna state in Nigeria, in the early 2010s, tractor subsidy programs, which distributed an average of 186 tractors per year with 25 percent subsidy rates, likely accounted for at least 10–20 percent of total state agricultural spending (Takeshima et al. 2015). While exact figures are not available, later flagship programs in various African countries focusing on the promotion of commercial machinery hiring services (e.g., Ghana's AMSEC (Agricultural Mechanization Service Enterprise Centers) and Nigeria's AEHE (Agricultural Equipment Hiring Enterprises), have continued to involve subsidized distribution of various machines like tractors (Resnick, Diao, and Tadesse 2020), possibly accounting for a significant share of overall agricultural spending in these countries.

## Adoption figures and their in-country heterogeneity in selected countries – the case of tractors

While overall mechanization levels have remained low across Africa south of the Sahara, it's perhaps more important to consider the significant heterogeneity in trends at subnational levels. The adoption rates of mechanization are challenging to estimate and often not reported in African countries, as machines (particularly those with higher horsepower per unit, like tractors) are adopted not only by owners but also by a large number of users who access them through hiring. Nonetheless, recently compiled agricultural household

surveys like the LSMS-ISA data and similar survey data provide national and subnational representative adoption rates.

Table 6.3 summarizes figures for four selected countries – Ethiopia, Ghana, Nigeria, and Tanzania – for which data are available, and where adoption rates are relatively higher than most other countries in Africa south of the Sahara (except perhaps Southern Africa). In these countries, adoption rates during the

### TABLE 6.3—TRACTOR ADOPTION RATES IN SELECTED AFRICAN COUNTRIES

| Country | Nationwide/subregions with higher adoption | Year | % using tractors % | % owning tractors % | Farm size (ha, all waves combined) Average (median) Tractor users | Farm size (ha, all waves combined) Average (median) Nonusers | Sources |
|---|---|---|---|---|---|---|---|
| Ethiopia[a] | Nationwide | 2013-2018 | 3 | 0.6 | 2.6 (1.8) | 1.4 (0.8) | LSMS-ISA |
| | Somali, Harari regions | 2013-2018 | 18 | 0.4 | 1.7 (1.4) | 1.4 (0.2) | LSMS-ISA |
| Ghana | Nationwide | 2009 2013 2018 | 13 15 18 | 0.6 0,2 0.2 | 3.4 (2.4) | 2.9 (1.6) | Socioeconomic Panel Survey |
| | North (Brong Ahafo, Northern, Upper East, Upper West under 10-region system) | 2009 2013 2018 | 29 35 38 | 0.6 0.5 0.4 | 3.7 (2.8) | 3.2 (2.0) | Socioeconomic Panel Survey |
| Nigeria | Nationwide | 2010 2012 2015 2018 2023 | 5 3 4 4 7 | 0.1 0.1 0.1 0.1 0.1 | 2.7 (1.8) | 1.2 (0.6) | LSMS-ISA |
| | North East | 2010 2012 2015 2018 2023 | 13 6 10 15 13 | 0.2 0.1 0.1 0.2 0.1 | 3.3 (2.0) | 2.1 (1.4) | LSMS-ISA |
| Tanzania | Nationwide | 2008 2010 2012 2014 2020 | 3 5 6 9 8 | 0.2 0.2 0.2 0.3 0.2 | 6.3 (3.1) | 2.3 (1.2) | LSMS-ISA |
| | Central-East corridor (Arusha, Manyara, Dodoma, Morogoro) | 2008 2010 2012 2014 2020 | 7 7 10 12 24 | 0.6 0.1 0.1 1.2 0.5 | 4.8 (2.7) | 2.4 (1.4) | LSMS-ISA |

Source: Authors' compilations based on various datasets.
Notes: LSMS-ISA: Living Standard Measurement Study – Integrated Survey on Agriculture. Figures are adjusted for sampling weights. aFigures for tractors for Ethiopia are average across all waves, given the low overall adoption levels.

late 2000s and most of the 2010s have ranged from around 3–18 percent nationally, with Ghana experiencing relatively faster growth (from 13 percent in 2009 to 18 percent in 2018).

A few key characteristics emerge. First, there is significant heterogeneity in adoption rates across regions within each country, with certain regions experiencing much higher and/or faster growth in tractor use (e.g., the Somali, Harari regions in Ethiopia, the Northern part of Ghana, the North East zone of Nigeria, and the Central-East corridor in Tanzania). While it is beyond the scope of this chapter to investigate the causes of such heterogeneity, the patterns are consistent with earlier studies (e.g., Diao, Takeshima, and Zhang 2020; Takeshima et al. 2015; Takeshima, Houssou, and Diao 2018) that noted how the use of tractors or mechanization more broadly can depend on both heterogeneous demand-side factors (e.g., spatial variations in agroecological and socioeconomic conditions) and supply-side factors (e.g., the significant roles of local government procurement and distribution as well as the limited spatial mobility of tractors, and the clustered nature of spare parts/repair service markets).

Second, albeit with some variations, the share of tractor users is considerably higher than the share of tractor owners (with ratios ranging from around 5:1 to roughly 100:1), confirming anecdotal evidence of the prevalence of custom-hiring services. Third, tractor users consistently cultivate larger farms than nonusers. While the second and third characteristics are intuitive and consistent with the literature, Table 6.3 further quantifies them in nationally representative ways.

## *Impact of Mechanization on Productivity and Resilience*

A growing body of literature has provided evidence on the effects of agricultural mechanization in recent decades. These effects span productivity, socioeconomic, and environmental dimensions, influencing both the average levels and the distributions of each outcome. Much of the evidence is at least semi-causal, suggesting that agricultural mechanization partly causes rather than simply responds to various changes in productivity and socioeconomic conditions. This section briefly highlights supplementary indicators of the associations between tractor use and key production/welfare outcomes, based on simple panel fixed-effects regressions using household survey data from selected countries in Africa south of the Sahara. The section also summarizes other evidence of the impact of

agricultural mechanization from the literature (primarily Africa south of the Sahara, but also from outside that region where relevant).

## Associations between tractor use and production/welfare outcomes based on primary farm household data

Using the aforementioned LSMS-ISA data and Socioeconomic Panel Data, we assess simple associations between household tractor use and various outcome indicators by

$$y_{it} = \alpha + \beta_M \cdot M_{it} + \beta_{MW} \cdot M_{it} \cdot W_i + \beta_Z \cdot Z_{it} + c_i + \varepsilon_{it}$$

in which $y_{it}$ is the set of outcomes by farm household $i$ in year $t$ (farm area cultivated, labor use for land preparation and plowing, total agricultural production value, yield measured as total agricultural production value divided by farm area cultivated, and total household consumption). $M_{it}$ is a binary indicator of tractor use. $W_i$ is a binary indicator of wetter agroecology (humid/subhumid zones based on FAO's agroecological zone definition), which we include to control for potential heterogeneity. $Z_{it}$ is a simple set of other control variables (household size, gender of household head, household asset value (natural log), and average education level of working age household members). Finally, $c_i$ is household fixed-effects, and $\varepsilon_{it}$ is an idiosyncratic error.

Tables 6.4 through 6.6 summarize the results for country-outcome combinations for which data are available. Table 6.4 shows that tractor use is associated with approximately 13–20 percent larger cultivated farm areas across all four countries studied, and 22 person-days less labor used for land preparation and/or plowing (in Ghana). These patterns are consistent with the findings elsewhere in the mechanization literature, which suggests that mechanization, like tractor use, is complementary to land and substitutes for labor (for specific operations).

Table 6.5 shows that using tractors is associated with greater total agricultural production value (in the order of 10–20 percent), while less significantly associated with yield (proxied by total agricultural production value per area cultivated). These findings are also broadly consistent with the mechanization literature, which suggests that tractor use leads to increased agricultural production more through land expansion rather than yield increase (Binswanger 1986; Diao, Takeshima, and Zhang 2020).

Lastly, Table 6.6 shows that using tractors is somewhat positively associated with total household consumption (after controlling for household

assets), consistent with the hypothesis that agricultural mechanization can contribute to household income growth.

Importantly, these results mask potentially significant heterogeneity and should be interpreted with caution, as it is also beyond the scope of this chapter to examine the heterogeneity in a comprehensive manner. Nonetheless, results at least indicate that no significant heterogeneity is observed between drier and wetter regions, suggesting that observed results may hold consistently across these two broad agroecological categories in each country.

While it is beyond the scope of this chapter to identify the true causal effects of tractor use, results in Tables 6.4 through 6.6 still provide valuable preliminary insights at the level of farm households from nationally representative samples in multiple countries in Africa south of the Sahara.

## Additional evidence from literature

Relative to regions outside of Africa south of the Sahara, where mechanization has been expanding for several decades, the direct econometric evidence of its impacts within that region remains limited in the literature. Nonetheless, some evidence is emerging.

### *Production and postharvest stage effects*

Echoing the findings presented in the previous section, tractor use has frequently been linked to larger cultivated areas, as shown in Nigeria using cross-sectional propensity score matching applied to LSMS-ISA data (Takeshima and Lawal 2020). The positive effects of tractor use on cultivated areas may be partly driven by increased returns to scale in production, which can shift comparative advantage from smaller to larger farms. In fact, a study in Ghana further shows that owning tractors directly raises returns to scale at the farm household level (Takeshima, Houssou, and Diao 2018). Nonetheless, evidence has been emerging that tractor adoption contributes to a significant increase in yield in Ghana (Benin 2015), particularly where such adoption occurs in areas with high yield potential and more intensive plowing has yield-enhancing effects (Takeshima and Liu 2020). Similarly, in Ethiopia, the use of combine harvesters has often been significantly associated with higher yields due to reduced harvest losses (Berhane et al. 2020). The observed positive effects on yield are consistent with emerging patterns in similarly

**TABLE 6.4—ASSOCIATIONS BETWEEN TRACTOR USE AND CULTIVATED AREA, LABOR USE FOR LAND PREPARATION IN SELECTED COUNTRIES**

| Dependent variable | Cultivated area (Natural log) | | | | Labor use for land preparation/plowing (person-days) |
|---|---|---|---|---|---|
| | Ethiopia | Ghana | Nigeria | Tanzania | Ghana |
| Variables | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) |
| Use tractor | 0.205** (0.086 | 0.109*** (0.031) | 0.141*** (0.039) | 0.142*** (0.040) | −21.981*** (6.902) |
| Use tractor × wetter region (yes = 1) | −0.108 (0.094) | −0.046 (0.065) | −0.030 (0.035) | −0.028 (0.039) | 2.066 (7.325) |
| Other controls[a] | Yes | Yes | Yes | Yes | Yes |
| Year × region dummies | Yes | Yes | Yes | Yes | Yes |
| Household fixed effects | Yes | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes | Yes |
| No obs. | 6,620 | 6,426 | 13,492 | 10,392 | 3,736[c] |
| p-value (H$_0$: variables jointly insignificant) | .000 | .000 | .000 | .000 | .000 |

Source: Authors.
Notes: ***1% **5% *10% †15%. [a]Other controls include household size, gender of household head, household asset value (natural log), and average education level of working age household members. [b]Wave 5 is excluded as the consumption figures have not been released yet for this wave. [c]Wave 1 is excluded as the labor use specific to land preparation/plowing has not been released yet for this wave.

smallholder-dominated, developing regions in Asia (Zhou and Ma 2020) and warrant further studies across Africa south of the Sahara in the future.

At the postharvest stage, evidence is also emerging of the significant effects of mechanization. Recently, in Nigeria, a quasi-experimental study showed that introducing solar-powered cold storage can significantly reduce losses and waste of perishable commodities, increase the prices received by farmers, and improve the overall quality of products (Takeshima et al. 2023).

### *Socioeconomic effects*

The aforementioned effects of mechanization on production and productivity are often also associated with significant economic impacts, albeit with considerable heterogeneity. In Zimbabwe, the use of tractors increases not only overall

## TABLE 6.5—ASSOCIATIONS BETWEEN TRACTOR USE AND AGRICULTURAL PRODUCTION VALUE, YIELD

| Dependent variable | Total agricultural production value (natural log) | | | Yield - agricultural production value per area (natural log) | | |
|---|---|---|---|---|---|---|
| | Ethiopia | Nigeria | Tanzania | Ethiopia | Nigeria | Tanzania |
| Variables | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) |
| Use tractor | 0.222** (0.112) | 0.220** (0.105) | 0.170** (0.071) | 0.142 (0.122) | 0.092 (0.104) | 0.033 (0.069) |
| Use tractor × wetter region (yes = 1) | −0.039 (0.114) | 0.015 (0.103) | −0.055 (0.065) | −0.054 (0.128) | 0.037 (0.102) | −0.026 (0.064) |
| Other controls[a] | Yes | Yes | Yes | Yes | Yes | Yes |
| Year × region dummies | Yes | Yes | Yes | Yes | Yes | Yes |
| Household fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes | Yes | Yes |
| No obs. | 5,474[b] | 12,268[b] | 7,814[b] | 5,474[b] | 12,268[b] | 7,814[b] |
| p-value ($H_0$: variables jointly insignificant) | .000 | .000 | .000 | .000 | .000 | .000 |

Source: Authors.
Notes: ***1% **5% *10% †15%. [a]Other controls include household size, gender of household head, household asset value (natural log), and average education level of working age household members. [b]Only include households reporting production values.

## TABLE 6.6—ASSOCIATIONS BETWEEN TRACTOR USE AND HOUSEHOLD CONSUMPTION

| Dependent variable | Household consumption (Natural log) | | | |
|---|---|---|---|---|
| | Ethiopia | Ghana | Nigeria | Tanzania |
| Variables | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) | Coef. (std.err) |
| Use tractor | 0.222** (0.112) | 0.142 (0.122) | 0.092 (0.104) | 0.033 (0.069) |
| Use tractor × wetter region (yes = 1) | −0.039 (0.114) | −0.054 (0.128) | 0.037 (0.102) | −0.026 (0.064) |
| Other controls[a] | Yes | Yes | Yes | Yes |
| Year × region dummies | Yes | Yes | Yes | Yes |
| Household fixed effects | Yes | Yes | Yes | Yes |
| Intercept | Yes | Yes | Yes | Yes |
| No obs. | 5,474[b] | 5,474[b] | 12,268[b] | 7,814[b] |
| p-value ($H_0$: variables jointly insignificant) | .000 | .000 | .000 | .000 |

Source: Authors.
Notes: ***1% **5% *10% †15%. [a]Other controls include household size, gender of household head, household asset value (natural log), and average education level of working age household members. [b]Wave 5 is excluded as the consumption figures have not been released yet for this wave.

production but also overall production revenue (Shonhe 2022). In Nigeria, the use of tractors is found to increase household incomes, particularly during the post-planting seasons, suggesting greater benefits from reduced land preparation costs resulting from tractors replacing hired labor or animal traction (Takeshima and Lawal 2020).

Several studies also provide direct evidence of labor savings from mechanization, including the use of tractors (e.g., Nigeria; Takeshima and Lawal 2020) and motorized tricycles (e.g., Ghana; Mueller et al. 2019). Recently, multi-country analyses using microdata from Ethiopia, Ghana, Nigeria, and Tanzania have shown that the use of tractors is mainly associated with reduced use of children's farm activities and increased school attendance (Vos and Takeshima 2021).

## Gender effects

Recently, a number of studies have provided insights into gender differences in these labor-use effects. In general, studies indicate that mechanization results in relatively greater reductions in women's agricultural labor compared to men's, accompanied by increased participation of women in non-agricultural activities – observed both at the cross-country level (Zhou and Ma 2022) and at the household level in selected countries in Africa south of the Sahara, including Ethiopia, Ghana, Nigeria, and Tanzania (Takeshima et al. 2024). At the same time, improved access to agricultural equipment such as tractors can enable youth – including young women – to engage in farming through independent enterprises with greater autonomy, rather than remaining as low-paid workers on family farms (e.g., Ghana; Mueller et al. 2019).

### Resilience, sustainability effects

Mechanization is also closely intertwined with resilience and improved sustainability, albeit in complex ways. Outside Africa south of the Sahara, the adoption and improvement of agricultural machinery have been found to enhance resilience against weather shocks, primarily by enabling more timely and speedy farming operations (e.g., sowing machines in Australia (Kingwell and Farré 2009) and harvesting machines in China (Wang et al. 2024)). While evidence remains limited in Africa south of the Sahara, a study in Nigeria suggests that mechanization can raise economies of scope and facilitate crop diversification (Takeshima, Hatzenbuehler, and Edeh 2020), potentially mitigating risks from biotic and abiotic shocks.

Improvements in machinery design can also mitigate adverse environmental effects. Historically, improvements in tractor design, such as the introduction of four-wheel drive (4WD) to generate tractive force with less overall weight and fewer slippages, helped mitigate soil compaction in developed countries (Rackham and Blight 1985). Similarly, two-wheel tractors, with their lighter weight, have the potential to alleviate soil compaction in Africa south of the Sahara (Baudron et al. 2015).

Efficient agricultural mechanization can reduce agricultural pollution and/ or fossil fuel consumption. For example, in Brazil, tractor plowing has replaced shifting cultivation and reduced fire burning (Morello et al. 2019). In Nigeria, the more economically efficient tractor service providers that remain competitive in the market are those that use less fossil fuel (such as diesel) per unit of land serviced, as fuel represents one of the most significant cost components in their operations (Takeshima et al. 2015). Technologies and efficient market structures enable the mitigation of the potentially harmful environmental effects of mechanization.

## Policy implications of observed impacts of agricultural mechanization

The observed impacts of agricultural mechanization (or associations between various outcomes and agricultural mechanization) described above have key policy implications. In particular, these patterns guide how mechanization support should be integrated into the agricultural and development policies of a particular country.

First, the associations observed in the regression results suggest that, within the overall agricultural sector policy framework, mechanization support should be better aligned with specific goals for which mechanization may be able to make a significant contribution. Specifically, such support should be integrated into the promotion of farm expansion, the growth of commercial farms, and agricultural income growth, while it should not be promoted as a primary instrument for certain goals such as yield enhancement (particularly among smallholders).

Second, agricultural mechanization should also be integrated into broader rural development and economic growth policies, not just agricultural policies. This is particularly important given that agricultural mechanization often reduces on-farm labor demand and can promote off-farm employment – including among women – as well as increased school attendance among children.

# Mechanization Case Studies and Success Stories across Africa

This section highlights some effective mechanization initiatives across Africa. To reflect continental diversity and scale, this section presents concise case vignettes across West, East/Horn, and Southern Africa, spanning land preparation, harvesting, and postharvest functions; public–private and private platform models; and finance/leasing innovations.

## Private platform-led service models

### Hello Tractor: digital mechanization services in Nigeria and Kenya

Hello Tractor is a technology-based platform that connects smallholder farmers with tractor owners through mobile applications and GPS tracked assets. The model reduces inefficiencies in tractor utilization by matching idle equipment with farmers in need of affordable mechanization services. In Nigeria and Kenya, it leverages mobile-based booking systems and GPS-tracked tractors, and is often referred to as the "Uber for tractors" (Daum et al. 2021). Studies estimate yield increases of 20–40 percent among participating farmers, depending on crop type and region (Van Loon et al. 2020). Hello Tractor's scalable model – operating through local booking agents and service aggregators – has enabled it to reach

over 500,000 smallholders, showing promise for replication across Africa (Daum et al. 2021). Moreover, the model supports job creation through local agents, mechanics, and telematics technicians while contributing to time savings and drudgery reduction, particularly for women and youth who engage in land preparation and postharvest tasks (Ajambo et al. 2023).

## Public–private hiring schemes

### Ghana's Agricultural Mechanization Services Centers (AMSECs)

Ghana's Ministry of Food and Agriculture launched the AMSEC model in response to low levels of mechanization among smallholder farmers. The initiative provides subsidized tractors and implements to private operators who, in turn, offer hiring services to farmers. By the mid-2010s, roughly 30 percent of Ghanaian farm households accessed mechanized land preparation services through AMSECs (Takeshima, Hatzenbuehler, and Edeh 2020). The model shows how public support can catalyze private service markets. Challenges include variable service quality and maintenance capacity; nonetheless, AMSECs remain a key reference for structured, PPP based delivery (Diao and Takeshima 2020).

### Rwanda: cooperative contracted rice harvesting and mobile threshing

In Rwanda's marshland rice zones, farmer cooperatives act as central agents in contracting combine harvesters and mobile threshers. They negotiate seasonal service agreements with private operators, covering fuel, logistics, breakdown response, and technician access (Takeshima et al. 2025). Payment is often performance-based – linked to area covered, quality, and timeliness, thereby reducing delays and postharvest losses.

Women lead in scheduling and aggregation, though ownership of mechanized assets remains constrained by gendered access to credit (FAO 2019). Nonetheless, the cooperative framework allows indirect participation and inclusive benefits, such as reduced drudgery, time savings, and enhanced food security outcomes. Evidence from districts such as Nyagatare and Bugesera shows postharvest losses have been reduced by up to 25 percent, with bulk contracting also lowering service costs (SAID Feed the Future 2020). Mechanization also enables double cropping in some areas by improving turnaround time between harvest and replanting (Rwanda, Ministry of Agriculture and Animal Resources 2021).

## Domestic manufacturing and local fabrication

### Ethiopia's local agricultural machinery manufacturing

Ethiopia has taken a localized approach by promoting domestic manufacturing and assembly of agricultural machinery. The government has supported this strategy by offering import duty exemptions for machine parts, facilitating public-private partnerships, and expanding vocational training in engineering. The Malabo Montpellier Panel report (2018) shows that this localized focus has helped Ethiopia adapt machinery designs to local conditions, such as fragmented land and specific crop needs. This approach has also stimulated entrepreneurship and reduced foreign dependency. Recent research emphasizes the importance of policy continuity and investment in R&D to further scale Ethiopia's machinery manufacturing sector (Deribe, Getnet, and Tesfaye 2021).

## Postharvest mechanization

### Southern Africa (Zambia/Malawi): community threshing/shelling hubs

Community-run threshing and shelling hubs have emerged as cost-effective, postharvest service models in Zambia and Malawi. Typically operated by cooperatives or farmer associations, these hubs use grant-seeded equipment (e.g., maize shellers, groundnut threshers) sustained through revolving funds or pay-per-use service fees (AGRA 2024). Machines rotate across wards on pre-booked schedules with trained youth or extension staff acting as operators and basic technicians.

Impact metrics from field evaluations show significant time and labor savings – up to 80 percent reduction compared to manual threshing – and up to 30 percent reduction in postharvest losses due to timely processing and reduced grain damage (Nath et al. 2024; Stathers, Onumah, and Lamboll 2024). The hubs also improve women's workload balance and enable aggregation of clean grain for collective marketing or storage.

Cost recovery models vary; in Zambia's Eastern Province, smallholder groups pay per 50kg bag or hectare, while in Malawi, pricing is sometimes subsidized during harvest peaks to improve access for low-income households (Tufa et al. 2023; Ngoma et al. 2023). Service utilization hinges on proximity, equipment uptime, and access to spare parts, with maintenance often supported by local agro-dealers or NGOs.

## Finance and leasing innovations

### *Nigeria/Ghana: dealer led leasing and vendor credit for mid range tractors*

In Nigeria and Ghana, dealer-led leasing models and vendor credit schemes have become key channels for expanding access to mid-range mechanization among emerging service providers and farmer groups. These models are often implemented through partnerships between tractor dealers, financial institutions (e.g., leasing firms, rural banks), and input/output aggregators (IFC 2021; AGRA 2024).

Under these schemes, equipment dealers co-develop financing packages that bundle tractor sales with embedded services, ranging from warranty coverage to operator training, the supply of spare parts, and maintenance scheduling. The use of vendor credit, in which repayment is linked to future earnings from mechanization service provision, reduces upfront capital barriers. Some models integrate telematics to monitor asset use, automate maintenance alerts, and reduce default risk (IFPRI 2022).

Service providers (often individual entrepreneurs, cooperatives, or agribusiness SMEs) recoup lease payments by offering hire services to farmer groups or through structured outgrower schemes. Studies suggest that repayment rates improve significantly when leasing is paired with seasonal cash flow projections, local maintenance capacity, and service demand aggregation (FSD Africa 2017). However, challenges persist in ensuring consistent after-sales service and managing risk in remote areas. Credit risk remains highest among first-time owners lacking collateral or diversified income sources (IFC 2012).

## *Conclusion and Outlook*

Agricultural mechanization is reasserting itself as a strategic pillar for Africa's agricultural transformation. As this chapter has shown, mechanization – when well targeted and sustainably scaled – can enhance productivity, reduce drudgery, improve farm incomes, and strengthen resilience to shocks. Mechanization is central to achieving the goals of CAADP, Agenda 2063, and the Malabo Declaration, yet its potential remains underutilized across much of the continent due to persistent structural, financial, and institutional barriers.

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**BOX 6.1—LESSONS FROM ASIA**

Experiences from Asia offer useful insights for mechanization in Africa south of the Sahara.

In Northeast Thailand, the adoption of two-wheel tractors grew from about 40,000 units in 1983 to 1.25 million by 2003 (Biggs and Justice 2015). This expansion was supported by local fabrication and reverse-engineering of imported machines, along with demand from producers of high-value aromatic rice varieties that economically justified more intensive mechanization (Mano, Njagi, and Otsuka 2023).

In China, since the early 2000s, local governments have played a key role in coordinating cross-regional combine harvesting services. Their support included operator training, seasonal harvest calendars, team formation, communication networks, and toll waivers, reducing costs and improving the safety and efficiency of service migration (Diao, Takeshima, and Zhang 2020).

*Lessons for Africa south of the Sahara: These experiences highlight the importance of promoting small, affordable machines through local manufacturing, especially in high-value crop systems, while also demonstrating how public institutions can play a critical coordination role in enabling efficient, low-cost mechanization services.*

Source: Authors.

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Custom-hiring services have emerged as the dominant and most scalable model for smallholder access to machinery. Initiatives like Hello Tractor in Nigeria, Ghana's AMSEC model, and Ethiopia's local manufacturing ecosystem illustrate successful pathways for expanding access. However, adoption remains uneven, with wide regional and subnational variation. This calls for flexible, data-informed policies that tailor support based on local needs – ranging from awareness and technical support in low-adoption areas to value-chain modernization in more mechanized zones.

The discussions of adoption patterns and trends in section 3 highlight the significant roles of custom-hiring services, which continue to serve as the primary means of access to mechanization for smallholders. Policies that strengthen the coordinating role of government – such as enhancing the technical capacity of mechanization service providers through training in machine operation, repair, and maintenance, and promoting digital platforms that reduce transaction costs for both providers and farmers – remain essential. The significant in-country heterogeneity of mechanization adoption rates across locations (also observed in section 3) further suggests that designing flexible support programs tailored to the specific needs of each subnational region also remains key. They may range from focusing on sensitization to mechanization benefits in low-adoption regions, technical support for custom-hiring services in medium-level adoption regions, and sustainable mechanization value-chain modernization in high-adoption regions. Such needs should be carefully identified through close coordination with local stakeholders.

Section 4 provides key insights into the impacts of mechanization and policy implications. While often promoted for productivity, mechanization in Africa tends to support farm expansion and household income growth more consistently than yield increases. Where yield enhancement is a goal, it should be pursued through bundled interventions, such as improved seed systems and better agronomy. The potential of mechanization to support gender inclusion should also be understood more broadly, capturing impacts on women's time, mobility, and engagement in off-farm employment. Likewise, its integration into environmental and climate policies is critical, warranting increased investment in R&D to generate region-specific solutions and evidence.

Sustainability and resilience must also guide future efforts. Climate-smart mechanization practices – such as minimum tillage, smart irrigation, and clean-energy solutions – should be incentivized. Mechanization can reduce vulnerability to climate shocks, but also introduces new risks, such as breakdowns and input dependency. Investments in local service ecosystems, infrastructure, and R&D will be essential to mitigate these risks and align mechanization with long-term environmental goals.

Advancing mechanization in Africa demands coordinated public-private investments, inclusive and flexible policy frameworks, and strong local

institutions. Looking forward, advancing mechanization in Africa requires clarity on next steps, responsibilities, and measurable outcomes.

- **Governments** should prioritize enabling policies, transparent subsidy frameworks, and budget allocations that expand access while avoiding market distortions.
- **Private sector actors** must invest in service delivery networks, leasing and finance models, and localized equipment innovations.
- **Development partners and research institutions** should provide technical assistance, impact evaluations, and capacity-building programs, especially for youth and women.
- **Local governments and communities** should coordinate service demand, maintain infrastructure, and ensure inclusive participation.

Progress should be measured by clear indicators such as rising adoption rates of mechanization, growth in the number and quality of service providers and technicians, reduction in drudgery for women and youth, increased share of climate-smart practices, and evidence of improved resilience to shocks. Mechanization will not, on its own, transform African agriculture – but when designed and implemented strategically, equitably, and sustainably, it can act as a powerful catalyst for rural transformation and food system resilience.